TRANSFORM HF Undergraduate Summer Research Program

The TRANSFORM HF Undergraduate Summer Research Program (USRP) gives students the opportunity to train alongside our multidisciplinary community of researchers to help address the grand challenge of inequity in heart failure care.

Students participating in the USRP will receive an award of up to $6,000, which must be supplemented by a $2,000 contribution from their research supervisors to ensure a minimum total stipend of $8,000 for a period of 16 weeks.

To be eligible, students must be registered at a Canadian academic institution as a full or part-time undergraduate student at the time of application. Up to two USRP awards are reserved for Indigenous students.

To apply, students must secure two faculty supervisors within TRANSFORM HF (one of which must be Faculty of Applied Science and Engineering-affiliated), and work with them to complete and submit an application. To facilitate this process, students may either:

- Consult the below list of established projects seeking an undergraduate summer student, and reach out to the associated supervisor for more information.
- Consult a list of faculty within the TRANSFORM HF network, and reach out to faculty members directly to inquire about potential projects.

If students wish to work with supervisors who are *not* already a TRANSFORM HF member, the supervisor must join the network in order for the student to apply for this opportunity.

Applications are due March 8, 2024 at 5:00pm EST.

1. ENGINEERING BIOELECTRONIC CARDIOVASCULAR DEVICES: IN-SITU STRAIN MEASUREMENTS IN CARDIOVASCULAR ORGANS-ON-CHIPS AND BIOFABRICATED IMPLANTABLE CARDIOVASCULAR TISSUES

Placement Duration

16-week from May-August 2024

Placement Location

Guenther Lab, University of Toronto

Project Description

Effective bioelectronic interfaces, capable of bidirectional communication with biological systems, are highly relevant for simulation and readout in human cell-based microphysiological systems. These technologies have applications in cardiovascular medicine for drug screening, implantable therapeutics, and as diagnostic solutions. Despite their promise clinical translation of these approaches remain limited, most notably due to insufficient mitigation of inflammatory responses and suboptimal long-term stability in dense cellular environments. In line with these challenges, our laboratory has previously developed an approach for the microfluidic preparation of handable ultra-thin (2 micron) collagen type-I sheets, with tunable anisotropy, robust directional fibrillar alignment, and d-periodic banding. Smooth muscle cells cultured on these substrates assumed directional fibril alignment and generated a coordinated contractile response in-vitro, while minimal inflammatory cell surface markers were observed indicating high cytocompatibility.

Responsibilities

The goal of this undergraduate summer research project is to render our aligned collagen sheets electrically conductive. The student will achieve this by depositing electrode patterns on top of collagen substrates, via sputter coating gold layers under vacuum using a shadow mask. The conductivity will be measured under hydrated (H20, 10X PBS) and dry conditions. Temporal changes in the conductivity will be evaluated by collecting readouts over a period of three weeks; 0 – 28 days at 7-day intervals. A strain gauge patterned using this technique will be evaluated as an approach that promises in-situ strain measurements in aligned collagen sheets for derived hierarchical biomaterials and cardiovascular tissues. This work will aid in the development of cardiovascular bioelectronics for modern medicine.

Contact Information

This project will be co-supervised by Dr. Axel Guenther. Please contact Chantel Campbell for more information (chantelbriana.campbell@mail.utoronto.ca)

2. INTEGRATING LARGE LANGUAGE MODELS INTO EXERCISE-BASED VIRTUAL CARDIAC REHABILITATION TO PROVIDE REAL-TIME ASSISTANCE TO HEART FAILURE PATIENTS

Placement Duration

May 6, 2024 – August 30, 2024

Placement Location

KITE Research Institute, Toronto Rehabilitation Institute, UHN

Project Description

Patients with heart failure often have reduced exercise capacity due to impaired heart function. Cardiac rehabilitation is a personalized standard of care program comprising supervised exercise, education and counselling aimed at restoring function, promoting healthy lifestyles and improving patients' quality of life. Virtual Cardiac Rehabilitation (VCR) programs offer at-home cardiac rehabilitation services that match the efficacy of traditional in-person programs. VCR has the potential to reduce the high dropout rates seen in in-person programs due to barriers, such as transportation, financial situations and staff shortages. However, for VCR platforms to be successful, automation is essential to enable patients to perform exercises at home without continuous supervision from clinicians. We have developed an AI-driven Virtual rehabilitation Assistant (AVA), a cloud-based intelligent avatar that works on any smart device with a webcam and can be accessed through a web browser. AVA monitors the body-joint movements of patients performing resistance training exercises in real time and evaluates correct exercise techniques using advanced deep learning models (e.g., spatiotemporal graph convolutional networks).

Recently, advancements in large language models have offered possibilities to provide generative textual (and audio) outputs from these models. This project aims to integrate pre-trained large language models into AVA. The movements of patients are converted into action tokens, which are then combined with the output of the deep neural networks and patients’ demographic information. This information will be entered into large language models that have been fine-tuned for VCR, which will enable them to generate real-time and personalized textual and audio feedback on patients' performance with their exercises. This guidance will be delivered through an animated avatar, which will instruct the patients on movement adjustments for improved safety and health outcomes. The effectiveness of AVA in delivering accurate feedback to patients will be validated through trials with actual heart failure patients at the Toronto Rehabilitation Institute. We expect that such interactive and engaging feedback will encourage safe and self-managed exercise at home, improve adherence to VCR programs, and boost patients' health outcomes.

Responsibilities

The selected student's primary duty will involve the development of deep learning models.

Requirements

Candidates for this role must be students in computer science, electrical engineering, biomedical engineering, or a similar discipline, with experience in applying deep learning algorithms to human activity recognition, including graph convolutional networks and Transformers, and proficiency in fine-tuning large language models.

Contact Information

This project will be co-supervised by Dr. Shehroz Khan and Dr. Tracey Collela. Please contact Shehroz Khan for more information (Shehroz.Khan@uhn.ca).

3. REMOTE OXYGENATION MONITORING OF TISSUE

Placement Duration

16-weeks from May-August 2024

Placement Location

Levi Lab, University of Toronto

Project Description

In the past decade, smartphones, and wearable devices (e.g., smartwatches) have become ubiquitous. We wish to use small, smartphone scale cameras to identify various vital sign measures from people in an unobtrusive manner. Signals of interest include but are not limited to blood pressure and blood oxygenation. Monitoring vital signs is key to tracking changing health conditions in elderly patients and in those recovering from heart surgeries. Our end goal is to develop measurement systems that are robust enough to be applied in real-world scenarios, allowing us to continually monitor vital sign information in a remote manner, without burdening the user. Moreover, we also wish to determine the simplest, cheapest, and most accessible technologies that are capable of achieving these goals. In this project, we aim to design and demonstrate a remote optical tissue oxygenation monitoring system that can quantize tissue oxygenation values at shallow tissue depths (~ 1-3 mm) from various distances (up to 2 meters away). To improve system motion robustness, we wish to leverage coherent illumination and structured light optimization techniques. Our intention is to apply this system towards both short or long-term patient health monitoring applications in clinical settings or for rapid health screening of large populations in high throughput scenarios.

Responsibilities

The student will focus on setting up an optical imaging system to collect data about tissue oxygenation values, from both tissue phantoms and subject hands in a controlled lab setting. This will include hardware and software integration for data acquisition and recording of oximetry values from different tissue penetration depths. Exploring the depth dependency on collected data such as light absorption and scattering, can be useful to develop more robust algorithms that compensate for depth variation. The student will be trained to work with different types of lasers as coherent sources and will study the unique phenomenon of coherent illumination. Various algorithms will be studied for optimizing structured light, including the use of a spatial light modulator. The student will be able to construct an overall understanding about light-tissue interaction, and design better systems that serve to measure tissue oxygenation level with remote optical settings.

Requirements

We are seeking a highly motivated Engineering students with experience in hardware and software integration who have completed at least two years of undergraduate studies by summer 2024. The student will be part of a dynamic interdisciplinary research team in the Levi lab and receive one-on-one mentorship with our graduate students. The students should be comfortable with open-ended problem solving and be willing to learn new concepts/skills from multiple engineering disciplines (e.g., biomedical, photonics, computer, electrical, mechanical, etc.). More details about the Levi lab and ongoing research directions can be found at: http://biophotonics.utoronto.ca.

Contact Information

This project will be co-supervised by Dr. Ofer Levi. To apply, please send the following to Sarvath.sharma@mail.utoronto.ca:

1) Subject Line: TRANSFORM HF Summer 2024 Opportunity
2) CV
3) Unofficial transcript

4. EVALUATING OPPORTUNITIES FOR AI IN DIGITAL MENTAL HEALTH SYSTEMS FOR PEOPLE WITH LIVED EXPERIENCE OF HEART FAILURE

Placement Duration
May 1, 2024 – August 30, 2024

Placement Location
Department of Mechanical and Industrial Engineering, U of T / Centre for Digital Therapeutics

Project Description
The student will be working on a project to evaluate AI and automation opportunities in the design of digital mental health systems for patients with heart failure and their families. We will be identifying opportunities to automate aspects of the digital mental health care process, while also considering the impact to health worker experience and improving equitable access to care. The student will be analyzing collected data and conducting a review of existing digital mental health processes using engineering methodologies.

Requirements
Experience with human factors, artificial intelligence and human centred design would be desirable, but we are open to all candidates.

Contact Information
This project will be co-supervised by Drs. Enid Montague and Quynh Pham. Please contact Dr. Montague for more information (enid.montague@utoronto.ca)

5. DESIGNING REGULATORY INFRASTRUCE FOR ML-BASED MEDICAL PRODUCTS

Placement Duration

May 1, 2024-August 31, 2024 (flexible start date as long as placement is 16 weeks)

Placement Location

Department of Electrical & Computer Engineering / Department of Philosophy, U of T

Project Description

There are now hundreds of machine learning (ML) based medical devices cleared by the US Food and Drug Administration (FDA) and their peer agencies in the EU and Canada for detection and in some cases diagnosis of disease. However, these devices are currently regulated using an outdated perspective that was developed in the 1960s for traditional software in medical applications, which overlooked all kinds of novel risks introduced by ML. Dr. Babic's prior work describes some of these risks in a highly cited paper published in Science, where they also argue that there is a need to revamp this regulatory infrastructure by using insights from ML-based software development and workflow.

The goal of the current project is to gain a better understanding of how to design the needed regulatory infrastructure for ML-based medical products through empirical and field experiments with industry partners, and through qualitative studies with a broad range of stakeholders developing medical ML products. We hope to engage regulators, medical manufacturers, and associated software developers to better understand the regulatory challenges and opportunities. We also hope to shed insight into future research directions in this interdisciplinary area of medical ML regulation.

Requirements

Strong background in computer science and/or machine learning. Strong familiarity with R and Python will be an important asset. Interest and ability to digest and summarize qualitative studies, interviews, surveys, and artifact analyses.

Contact Information

This project will be co-supervised by Drs. Shurui Zhou and Boris Babic. It will also involve close collaboration with stakeholders who develop AI-enabled medical devices. Please contact Dr. Zhou for more information (shuruiz@ece.utoronto.ca).